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Macroeconomic Effects of Intellectual Property Rights: An Updated Survey

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Abstract

This paper provides a survey of studies that analyze the macroeconomic effects of intellectual property rights (IPR). The first part of this paper introduces different patent-policy instruments and reviews their effects on R&D and economic growth. This part also discusses the distortionary effects and distributional consequences of IPR protection as well as empirical evidence on the effects of patent rights. Then, the second part considers the international aspects of IPR protection. In summary, this survey draws the following conclusions from the literature. First, different patent-policy instruments have different effects on R&D and economic growth. Second, there is some empirical evidence supporting a positive relationship between IPR protection and innovation, but the evidence is stronger for developed countries than for developing countries. Third, the optimal level of IPR protection should tradeoff the social benefit of innovation against the social costs of multiple distortions and income inequality. Finally, in an open economy, achieving the globally optimal level of protection requires an international coordination (rather than the harmonization) of IPR protection.

JEL classification: O31, O34, O40, F13
Keywords: economic growth, innovation, intellectual property rights

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1 Introduction

In the first year of graduate coursework in economics, students are often encountered with the following important and perhaps surprising theoretical result. The first fundamental theorem of welfare economics states that any competitive or Walrasian equilibrium leads to a Pareto efficient allocation of resources. In other words, competitive markets are efficient. Therefore, governments should simply let the market do its work and the market outcome will be Pareto efficient. However, in reality, the ideal conditions of perfect competition are not necessarily satisfied. In this situation, we may have market failures in over-providing or under-providing certain economic activities. An important example is investment in research and development (R&D). There is an established empirical finding that the social return to R&D is much higher than the private return.[1] Jones and Williams (1998, 2000) develop an R&D-based growth model and use these empirical estimates to show that the socially optimal level of R&D is at least two to four times higher than the market level. Therefore, overcoming this market failure would increase R&D towards the socially optimal level as well as increasing innovation, economic growth and social welfare. The purpose of this paper is to provide a selective survey of studies that analyze the macroeconomic effects of intellectual property rights (IPR).

The seminal study of the patent-design literature is Nordhaus (1969), who concludes that the optimal patent length should balance the static distortionary effect of patent protection and the dynamic gain from innovation. While Nordhaus (1969) considers only patent length, Gilbert and Shapiro (1990) analyze the optimal combination of patent length and patent breadth and argue that the socially optimal policy combination is an infinite patent length and a minimum degree of patent breadth. Although this result does not necessarily hold in a more general model as shown in Klemperer (1990), Gilbert and Shapiro (1990) provide one of the first studies on the optimal combination of patent-policy instruments. A comprehensive review of the subsequent developments in this literature can be found in Scotchmer (2004). While most studies in the patent-design literature are based on a qualitative partial-equilibrium setting, a quantitative dynamic general-equilibrium (DGE) analysis becomes important when one wants to consider the macroeconomic implications of raising IPR protection. The following quote reflects the importance of such an analysis.

> [T]here is much to be done to understand the pace of technological progress in frontier economies. Our models of endogenous technological change give us the basic framework for thinking about how profit incentives shape investments in new technologies. [...] But most of our understanding of these issues is qualitative. For example, in the context of the economics of innovation, we lack a framework – similar to that

[1] See Griliches (1992) for a review of this literature.

> used for the analysis of the effects of capital and labor income taxes and indirect taxes in public finance – which could be used to analyze the effects of [...] IPR policies [...] on innovation and economic growth.
>
> – Daron Acemoglu (2009, p. 873)

This survey article is structured as follows. The first part (Sections 2-4) introduces the different patent-policy instruments, such as patentability requirement, patent length and patent breadth, and reviews their effects on R&D and innovation using the celebrated R&D-based growth model of Romer (1990) and its subsequent developments as the conceptual framework. In this part of the paper, I also discuss various distortionary effects and the distributional consequences of raising IPR protection as well as empirical evidence on the effects of patent rights. Then, the second part (Sections 5-6) considers the international aspects of IPR protection. In summary, this survey draws the following conclusions from the literature. First, different patent-policy instruments can have positive, insignificant or even negative effects on R&D and growth. Second, there is some empirical evidence for a positive relationship between IPR protection and innovation, but the evidence seems to be stronger for developed countries than for developing countries. Third, the optimal level of patent protection should tradeoff the social benefit of innovation against the social costs of multiple distortions and income inequality. Finally, in an open economy, achieving the globally optimal level of protection requires an international coordination (rather than the harmonization) of IPR protection.

2 Patent policy instruments

Patent policy has multiple instruments that can be used to affect the incentives for R&D and innovation.[2] One instrument is the patent length that determines the statutory term of patent. In most countries, a patent has a statutory length of 20 years as a result of the TRIPS agreement.[3] Although this instrument can be easily measured by the number of years for which an invention is protected, extending the patent length beyond 20 years is unlikely to be an effective way to increase R&D in most industries.[4] In some countries, to maintain the legal status of a patent requires a patent maintenance fee. For example, in the US, patent maintenance fees were

[2] See Chu (2021) for a more technical survey with a formal presentation of these instruments.

[3] The World Trade Organization (WTO) Agreement on Trade-Related Aspects of Intellectual Property Rights (TRIPS), initiated in the 1986-94 Uruguay Round, establishes a minimum level of IPR protection to be provided by all member countries by 2006.

[4] An important exception would be the pharmaceutical industry. The effectiveness of patent protection varies across industries, and it is well known that patent protection is especially effective in the pharmaceutical industry. See Chu (2008) for an analysis on the implications of pharmaceutical companies lobbying the US government for extending the patent length on drugs.

initiated in 1982. Currently, the fees are due 3.5 years ($2000), 7.5 years ($3760) and 11.5 years ($7700) after a (utility) patent is granted. In some European countries, this fee is due annually. Therefore, if most patents are not renewed until the end of the statutory term, then we may conclude that increasing the statutory patent length would not be an effective way to increase R&D because an average patent after being granted for a certain period of time is not worth as much as the patent maintenance fee. Schankerman and Pakes (1986) indeed find that about half of all patents are not renewed within 10 years and only 10% of them are renewed until the end of the statutory term in their sample of European countries. Similarly, a recent study by Bessen (2008) estimates a flow-profit depreciation rate of 14% for US patents. In other words, the amount of profits earned by an average patent decreases at an annual rate of 14%. Suppose a patent generates $X per year today. Using a 14% flow-profit depreciation rate, this patent will generate only 6% of $X per year after 20 years. Given the estimated flow-profit depreciation rate and the interest rate, one can do a simple partial-equilibrium calculation (i.e., holding the depreciation rate and the interest rate constant) to show that extending the patent length beyond 20 years would lead to a very small percent increase in the market value of patents; see Chu (2010a).

A number of studies analyze optimal patent length in DGE models. For example, Judd (1985) finds that the optimal patent length is infinite while Iwaisako and Futagami (2003) and Futagami and Iwaisako (2007) find that the optimal patent length can be finite in a version of the Romer model.[5] While it is an interesting and important theoretical question to explore the optimal duration of patent, a more relevant question in terms of policy implications is perhaps the magnitude of welfare gains from changing the patent length to its socially optimal level. An important first study that analyzes the quantitative implications of patent extension in a DGE model is Kwan and Lai (2003), who find that extending the effective lifetime of patent would lead to a substantial increase in R&D and welfare. Kwan and Lai (2003) use the same production function as in the original Romer model that imposes a restriction on the markup and capital share. This usually innocuous setup restricts the flow-profit growth rate of each patent to equal the labor-force growth rate that is nonnegative,[6] and this counterfactual implication leads to an

[5] These different results arise for the following reason. In Judd (1985), the relative-price distortion disappears at an infinite patent length for which all goods are subject to equal monopolistic pricing. In Iwaisako and Futagami (2003) and Futagami and Iwaisako (2007), there is an additional distortion on the allocation of intermediate goods, and this distortionary effect can be reduced by shortening the patent length.

[6] This setup is innocuous for an endogenous growth model that does not deal with IPR-related issues. However, when it comes to analyzing the effects of patent length, restricting the flow-profit growth rate g_π of patent to be nonnegative is problematic and counterfactual. In brief, the restriction arises from $g_\pi = g_Y - g_A$, where g_Y denotes output growth and g_A denotes the growth rate of varieties that is equal to the growth rate of total factor productivity in the Romer model. Therefore, the Romer model implies that $g_\pi \geq 0$ while empirical studies, such as Bessen (2008),

upward bias on the effects of patent length on R&D. Using an extended version of the Romer model to match the empirical flow-profit depreciation rate of patent, Chu (2010a) finds that extending the patent length beyond 20 years leads to a negligible increase in R&D and consumption while shortening the patent length leads to their significant reduction. In other words, patent length on average loses its effectiveness on R&D at roughly 20 years.

Given that patent length is not an effective instrument in increasing R&D in most industries, it is perhaps not surprising that the patent reform in the US initiated in the 1980's was related to other aspects of patent rights, such as lowering the patentability requirement and broadening the patent breadth.[7] We discuss each of these instruments in turn. To obtain a patent for an invention in the US, the invention has to be novel and non-obvious. The non-obviousness requirement states that a patentable invention must not be obvious to a person skilled in the art. These novelty and non-obviousness requirements are often referred to as the patentability requirement. Using the Schumpeterian growth model in Aghion and Howitt (1992) in which innovation takes the form of higher-quality products,[8] O'Donoghue and Zweimuller (2004) show that lowering the patentability requirement (i.e., the required inventive step size modeled as a policy-imposed lower bound on the size of each quality improvement) has opposing effects on R&D and innovation; see also Hunt (1999) and Koleda (2004). On the one hand, it increases the incentives for R&D by making it easier for an inventor to obtain a patent. On the other hand, it decreases the incentives for R&D by reducing the amount of profits generated by an invention due to its smaller quality improvement and by raising the chance that the next invention is patentable and takes away market share from the current invention. It can be shown that the profit-maximizing inventive step size is below the growth-maximizing step size due to the positive externality of product quality on economic growth. Therefore, the policy implication is that lowering the patentability requirement has a theoretically ambiguous effect on R&D and growth. A recent study by Kiedaisch (2015) finds that lowering the patentability requirement stimulates innovation by increasing entrants' pressure on incumbents to innovate in a Schumpeterian growth model with persistent leadership.

Patent breadth refers to the broadness or the scope of a patent. When an inventor applies for a patent to protect her invention, she makes a number of claims about this invention to be reviewed by a patent examiner. Patent breadth determines how specific these claims must be, and specific claims are unlikely to be infringed upon (i.e., ineffective patent protection). In an environment with sequential innovations, patent breadth determines the level of patent protection for an invention against imitation and subsequent innovations. The former type of patent protection is

find that $g_{\pi} < 0$.

[7] See Jaffe (2000), Gallini (2002) and Jaffe and Lerner (2004) for a discussion.

[8] See also Grossman-Helpman (1991a) and Segerstrom *et al.* (1990) for other early studies.

referred to as lagging breadth while the latter type of protection is referred to as leading breadth.

Using the Schumpeterian growth model, Li (2001) provides an analysis of lagging breadth on R&D and growth and finds a positive effect. In other words, increasing protection against imitation improves the incentives for R&D. Li (2001) considers an environment in which larger lagging breadth allows monopolistic firms to charge a larger markup, and hence, the positive effect on innovation follows; see also Goh and Olivier (2002), Chu (2011) and Saito (2017) who explore optimal patent breadth in the presence of multiple R&D sectors. Some subsequent studies show that increasing patent protection against imitation can have negative effects on R&D and growth. Furukawa (2007) considers a model in which machine usage in the past has a positive effect (learning by experience) on current productivity of final goods, whereas Horii and Iwaisako (2007) consider a model in which R&D is more effective in competitive industries than in patent-protected industries. Therefore, when a higher level of IPR protection increases the number of monopolistic industries relative to competitive industries, it decreases the learning-by-experience effect in Furukawa (2007) and the average R&D productivity in Horii and Iwaisako (2007). Chin (2007) considers an overlapping-generation (OLG) model and shows that when IPR protection has asymmetric effects on different generations of households, it may also have a negative effect on innovation.[9] Iwaisako and Futagami (2013) find that the opposing effects of patent breadth on R&D and capital investment generate an inverted-U growth effect of patent protection in a growth model with innovation and capital accumulation.[10] Chu, Furukawa and Ji (2016) and Chu, Kou and Wang (2020) show that a larger patent breadth increases the number of products and reduces economic growth by decreasing the amount of resources available for quality-improving R&D in each product. A recent study by Chu, Cozzi, Fan, Pan and Zhang (2020) finds that in an R&D-based growth model with credit constraints, a larger patent breadth could tighten the credit constraints and stifle innovation by worsening monopolistic distortion.

As for leading breadth, this instrument gives the patentholders property rights over future inventions. Due to these overlapping patent rights, the current generation of inventors may have to share their profits with the previous generations of inventors. Therefore, increasing leading breadth has opposing effects on the incentives for R&D. O'Donoghue and Zweimuller (2004) analyze the effects of leading breadth in the Schumpeterian growth model. On the one hand, the consolidation of market power across generations of inventors increases the amount of profits captured by an invention that leads to a positive effect on R&D. On the other hand, the lower present value of profits received by an inventor due to delayed rewards

[9] Wu and Chou (2004) consider both public and private protection for IPR and find that increasing public protection for IPR may decrease innovation depending on the degree of complementarity between public and private protection for IPR.

[10] Yang (2021) extends their analysis to consider the welfare implications of patent breadth.

from profit sharing leads to a negative effect provided that the interest rate is higher than the profit growth rate. This negative effect of leading breadth is often referred to as blocking patents.[11] Based on detailed case studies, Jaffe and Lerner (2004) conclude that stronger patent rights may have adverse effects on R&D by preventing or delaying subsequent inventors from launching their higher-quality inventions.[12] Chu (2009b) builds on the model in O'Donoghue and Zweimuller (2004) to provide a quantitative analysis on the effects of blocking patents and find that reducing the negative effect of blocking patents on R&D would lead to a significant increase in social welfare. Therefore, Chu (2009b, 2010a) together provide a comparison on the relative effectiveness of extending the patent length and reducing the negative effect of blocking patents on R&D and innovation. The difference between these two policy instruments is that extending the patent length increases future profits while reducing the negative effect of blocking patents raises current profits for an inventor. Some subsequent studies consider different extensions of the Schumpeterian growth model and find an inverted-U effect of blocking patents on economic growth; see Chu, Cozzi and Galli (2012) and Niwa (2016) for a model with both quality improvement and new product development, Chu and Pan (2013) for an endogenous step size of quality improvement and Cozzi and Galli (2014) for a model with a two-stage cumulative innovation structure.

As for future research, the literature still lacks a standardized growth-theoretic framework that can be used to evaluate the effects of patent policies quantitatively as the quote from Acemoglu (2009) in the introduction suggests. Although some of the above studies provide an attempt to fill this gap in the literature, we still lack a systematic framework that can be used to simultaneously analyze the quantitative effects of multiple patent-policy instruments as well as their optimal combination. Exceptions include Chu and Furukawa (2011) and Yang (2013), who consider the optimal coordination of patent breadth and a profit-division rule in research joint ventures, and Yang (2018), who considers the optimal coordination of blocking patents and patent breadth.

3 Empirical evidence on the effects of IPR

To investigate the effects of IPR protection on economic growth, empirical studies often employ a cross-country regression analysis. In this type of empirical frame-

[11] Acs and Sanders (2012) also show that stronger patent rights may decrease R&D by transferring an excessive amount of profits from second-generation inventors to first-generation inventors.

[12] Jaffe and Lerner (2004) provide a detailed and insightful case-study analysis and argue that the strengthening of patent rights in the US initiated in the 1980's has converted the patent system from a stimulator of innovation to a creator of litigation that results into negative effects on innovation. This is because current patentholders can now use their enhanced bargaining power to stifle future innovations.

work, a common measure of national IPR protection is the index of patent rights constructed by Ginarte and Park (1997) and extended by Park (2008a). Ginarte and Park (1997) examine five categories of patent rights and assign a score from zero to one to each category.[13] Then, the IPR index is a simple sum of these scores on a scale of zero to five, and a larger number indicates stronger patent rights. The updated IPR index from Park (2008a) is available for 122 countries from 1960 to 2005 with one observation for each 5-year interval.

A number of empirical studies, such as Varsakelis (2001), Kanwar and Evenson (2003) and Park (2005), use this index to evaluate the effects of patent rights on R&D and find a positive relationship.[14] However, upon separating developed and developing countries, the effects of patent rights in developing countries become ambiguous. For example, while Chen and Puttitanun (2005) find that IPR protection in developing countries has a positive and significant effect on innovation, Park (2005) finds that it has an insignificant effect on R&D. Falvey *et al.* (2006) find that IPR protection has a positive and significant effect on growth in low-income and high-income countries but not in middle-income countries. Hu and Png (2013) employ industry-level data to show that stronger patent rights stimulate the growth of patent-intensive industries and that this effect is more significant in higher-income countries. Chu, Cozzi and Galli (2014) find that for a country that is far away from the global technology frontier, the effect of patent rights on economic growth is negative, whereas for a country that is close to the technology frontier, the effect of patent rights on economic growth becomes positive. Chu, Cozzi, Fan, Pan and Zhang (2020) use an alternative index of patent protection constructed by Papageorgiadis *et al.* (2014) and find that patent protection also has a positive (negative) effect on innovation under a high (low) level of financial development.

Therefore, one can draw the following conclusion from this empirical literature. While empirical studies find supportive evidence for a positive relationship between IPR and innovation, the evidence seems to be stronger for developed countries than for developing countries. A plausible interpretation on this finding is that developed countries are usually close to the technology frontier, so that economic growth in these countries requires original innovations. In contrast, developing countries are usually further away from the technology frontier, so that economic growth can be driven by the reverse engineering of foreign technologies. As a result, stronger patent rights that discourage the reverse engineering of foreign technologies may stifle the innovation process in developing countries; see Chu, Cozzi and Galli (2014) for this theoretical result in a Schumpeterian growth model.

Finally, while the theoretical literature suggests that patent protection has both positive and negative effects on economic growth, empirical studies tend to find a

[13] The five categories are (a) patent duration, (b) coverage, (c) enforcement mechanisms, (d) restrictions on patent scope and (e) membership in international treaties.

[14] See Park (2008b) for an excellent survey of this empirical literature.

positive effect in developed countries. This empirical finding implies that the negative effects of IPR protection are dominated by the positive effects. An important caveat here is that the commonly-used empirical measure of patent protection is a summary statistics on various categories of patent rights, and it is not clear as to how each type of patent rights affects innovation empirically. Therefore, it would be interesting if future empirical studies could investigate the effects of the different patent-policy instruments on innovation. Furthermore, existing empirical studies mostly focus on the effects of *domestic* patent protection on *domestic* innovation. However, an open question in the open-economy theoretical literature (to be discussed in the second part of this survey) is that whether stronger IPR protection in the South improves or stifles innovation in the North. Therefore, it would be interesting if future empirical studies could shed some more light on this issue.

4 Distortionary effects and distributional consequences of IPR protection

This section discusses the harmful effects of IPR protection on the society. In undergraduate microeconomics, students learn that monopoly imposes a harmful deadweight loss on the society. When policymakers increase the level of patent protection, it is like conferring more market power to monopolists that amplifies this deadweight loss. As mentioned before, Nordhaus (1969) shows that the optimal level of patent protection should tradeoff this harmful effect against the welfare gain from innovation. To capture this distortionary effect in a general-equilibrium model, patent protection can be modeled as allowing monopolists to charge a larger markup and for a longer period of time. In this case, the harmful effect of patent protection can be captured as a relative-price distortion (i.e., the markup price distorts the relative consumption between monopolistic goods and competitive goods from the socially optimal level), and this distortion leads to a welfare loss as shown in O'Donoghue and Zweimuller (2004). Furthermore, patent protection creates other distortions in a general-equilibrium setting. For example, in a model with elastic labor supply, the monopolistic markup affects the real wage and distorts labor supply; see Chu, Pan and Sun (2012) who show that the presence of this distortionary effect on labor supply depends on whether the model features the knowledge-driven or lab-equipment innovation process. Similarly, in a model with endogenous capital accumulation, the monopolistic markup creates a wedge between the social marginal product of capital and its rental price and hence distorts the share of output devoted to capital investment as shown in Chu (2009b, 2010a). Chou and Shy (1993) show that in an OLG model, the presence of monopolistic profits created by patent protection leads to an additional distortion on innovation through the crowding-out effect on the portfolio space of the young generation.[15]

In addition to these distortionary effects, strengthening patent protection may also worsen income inequality via two channels: (a) wage inequality and (b) asset-income inequality. Provided that income inequality is a social concern, these distributional consequences should also be taken into consideration. When there are skilled and unskilled workers, stronger patent rights would increase wage inequality by increasing the return to R&D and the wage of R&D workers, who are mostly skilled labor. For example, Cozzi and Galli (2014) extend the Schumpeterian growth model to provide a quantitative analysis on the effects of patent protection on wage inequality in the US. Chu (2010b) and Chu and Cozzi (2018) also analyze the distributional consequences of patent policy in the US but considers the effects on income inequality from an unequal distribution of wealth among households. In this case, an increase in the level of patent protection increases the real interest rate through the Euler equation; consequently, the income of asset-wealthy households increases relative to asset-poor households. A recent study by Chu, Furukawa, Mallick, Peretto and Wang (2020) shows that although a higher level of patent protection increases income inequality in the short run as in previous studies that feature an exogenous number of differentiated products, patent protection reduces income inequality in the long run when the number of differentiated products adjusts endogenously. They use a panel vector autoregression to provide empirical support for this theoretical result and also calibrate the theoretical model to data to simulate the dynamic effects of patent protection on income inequality in the US.

Chu, Furukawa, Mallick, Peretto and Wang (2021) assume homothetic preferences under which the income distribution does not affect the aggregate economy. Foellmi and Zweimuller (2006) develop an R&D-based growth model in which the income distribution affects the aggregate economy due to non-homothetic preferences of heterogeneous households. Extending the model in Foellmi and Zweimuller (2006) to explore the effects of patent protection, Kiedaisch (2021) finds that the overall effect of patent protection on economic growth is ambiguous and depends on the underlying income distribution.

[15] Chou and Shy (1993) consider the portfolio crowding-out effect firstly analyzed by Laitner (1982), who shows that in an OLG model, the presence of monopolistic profits creates the usual static (relative-price) distortion as well as a dynamic distortion on capital accumulation by crowding-out the young generation's saving devoted to investment in tangible capital through the purchase of monopolistic firms. Chou and Shy (1993) use this concept to analyze the crowding-out effect of patent extension. They show that in an OLG model with product development, the market value of existing inventions crowds out the young generation's saving devoted to investment in new product development, and extending the patent length worsens this crowding-out effect.

5 IPR protection in an open economy

This part of the paper considers the international aspects of IPR protection. In the previous section, we see that the optimal level of patent protection should tradeoff the welfare gain from innovation against the welfare losses from distortions and possibly income inequality. However, due to the positive externality of patent policy across countries, the Nash equilibrium level of IPR protection may be suboptimal. Intuitively, when each country chooses the domestic level of IPR protection to maximize the welfare of domestic households without taking into consideration the benefits of technology spillovers on foreign households, the non-cooperative equilibrium level of IPR protection would be suboptimally low.

Using an open-economy version of the Romer model, Lai and Qiu (2003) and Grossman and Lai (2004) show that the Nash equilibrium level of IPR protection is indeed below the globally optimal level due to the spillover effects of innovation across countries. Also, they find that (a) developed countries (the North) would choose a higher level of IPR protection than developing countries (the South) due to their asymmetry in innovative capability, (b) imposing the North's level of IPR protection on the South as required by TRIPS would lead to a welfare gain (loss) in the North (South), and (c) the harmonization of IPR protection required by TRIPS is neither necessary nor sufficient for maximizing global welfare. Chu and Peng (2011) extend the analysis of Lai and Qiu (2003) and Grossman and Lai (2004) by considering the effects of IPR protection on income inequality across countries. They find that stronger patent rights in one country would lead to an increase in economic growth and income inequality in both domestic and foreign countries. In summary, the conclusions from this literature are that (a) an international coordination (rather than the harmonization) of IPR protection is key to global welfare improvement and (b) it is important to take into consideration the distributional implications of TRIPS on developing countries (see below for the case of China as an example).

Before joining the WTO in 2001, China reformed its patent system in compliance with TRIPS.[16] After this policy reform, the annual growth rate of patent applications in China increases to 23% (compared to less than 10% before 2000). Hu and Jefferson (2009) show that the patent reform in 2000 is a major factor for this surge in patenting activities. In addition, R&D as a share of GDP in China increases from an average of 0.7% in the 90's to 1.49% in 2007. At the same time, the rising income inequality in China becomes a potential threat to the country's stability. In 2007, China's Gini coefficient rises to 0.47 that is above the threshold of 0.45 indicating potential social unrest. For example, the United Nations Development Programme

[16] The changes include (a) providing patent holders with the right to obtain a preliminary injunction against the infringing party before filing a lawsuit, (b) stipulating standards to compute statutory damages, (c) affirming that state and non-state enterprises enjoy equal patent rights, and (d) simplifying the patent application process, examination and transfer procedures and unifying the appeal system.

(2005) "... warned that the growing income gap between rich and poor in China could threaten its stability, saying Beijing should increase social spending, reform the fiscal system and push government reforms to narrow the gap." A policy implication from Chu and Peng (2011) is that increasing IPR protection as a result of TRIPS has contributed to the rising income inequality in China, and this theoretical prediction is supported by the empirical finding in Adams (2008). Adams (2008) uses the Ginarte-Park index and finds that strengthening IPR protection has a positive and statistically significant effect on income inequality in developing countries.

6 Foreign direct investment and product cycles

An important feature of the theoretical models in Lai and Qiu (2003), Grossman and Lai (2004) and Chu and Peng (2011) is that both the North and the South engage in innovative R&D. However, for analytical tractability, these studies abstract from some interesting issues, such as imitation from the South and technology transfer from the North. These issues are considered in a related literature, which analyses the effects of strengthening Southern IPR protection on Northern innovation through a decrease in imitation from the South and an increase in technology transfer from the North via foreign direct investment (FDI). Although these studies usually make the common simplifying assumption that innovative activities only take place in the North,[17] they tend to find contrasting effects of Southern IPR protection on Northern innovation.

Grossman and Helpman (1991b) develop a North-South product-cycle model with endogenous innovation in the North and endogenous imitation in the South. Surprisingly, they find that strengthening Southern IPR protection either has no effect or a negative effect on Northern innovation.[18] Lai (1998) shows that whether Southern IPR protection (modeled as a parameter that affects the rate of imitation in the South) has a positive or negative effect on Northern innovation depends on the mode of technology transfer. If technology transfer occurs within multinational firms via FDI, then Southern IPR protection has a positive effect on Northern innovation. On the other hand, if technology transfer occurs via imitation (i.e., Southern firms copying the products of Northern firms), then the opposite is true. Lai (1998) considers a North-South product-cycle model in which imitation is exogenous and

[17] See Grossman and Helpman (1991b), Helpman (1993), Lai (1998), Yang and Maskus (2001) and Glass and Saggi (2002b). For example, Glass and Saggi (2002a) consider a model with two symmetric innovating countries. Chui *et al.* (2001) consider a North-South growth model in which there are different stages of development in the South (from low-skill manufacturing to imitation and then innovation); however, their general model needs to be analyzed numerically. See Li and Qiu (2014) for a survey of this literature.

[18] To be precise, Grossman and Helpman (1991b) consider a tax (subsidy) on imitation that decreases (increases) Southern imitation, which is similar to the effects of IPR protection.

technology transfer to the South does not require adaptive R&D by Southern firms (i.e., costless FDI). Both of these assumptions are relaxed in subsequent studies. Dinopoulos and Segerstrom (2010) consider a model in which Northern firms invest in innovative R&D and their Southern affiliates invest in adaptive R&D for transferring technology from the North. Consistent with Lai (1998), they find that strengthening Southern IPR protection (i.e., a decrease in the probability of Southern affiliates' technology being copied by other Southern firms) would increase the incentives for (a) innovation in the North and (b) technology transfer to the South. In a related study, Dinopoulos and Segerstrom (2007) consider a model in which technology transfer to the South is via endogenous imitation of Northern products. In this model, they find that stronger IPR protection reduces imitation of Northern products; as a result, more production remains in the North and less resources are available for innovative R&D. It is worth noting that Dinopoulos and Segerstrom (2007, 2010) consider two polar cases of either FDI or imitation as the channel of technology transfer.[19] However, they conjecture that in a more general model, whether Southern IPR protection has a positive or negative effect on Northern innovation should depend on the relative importance of FDI and imitation on technology transfer.[20] Empirically, Park (2012) finds that strengthening patent protection in developing countries causes insignificant effects on R&D investment of multinational firms and their foreign affiliates in developed countries.

Chu, Cozzi and Furukawa (2015) use a North-South version of the model of directed technical change originated from Acemoglu (2002) to explore the implications of IPR protection in the South on the *direction* of innovation in the North. They find that patent protection and offshoring are both channels for Southern labor endowment to affect the market size for Northern inventions. Specifically, absent offshoring and lacking patent protection in the South (as in China in the early 1980s), an increase in Southern unskilled labor leads to skill-biased technical change, which refers to a reallocation of innovation resources from labor-intensive products to skill-intensive products. If instead offshoring is present and/or patent protection is better enforced (as in more recent times), then a decrease in unskilled labor in China leads to an increase in the skill premium in China through skill-biased technical change in the US.

7 Conclusion

This paper surveys studies that analyze the macroeconomic effects of IPR protection and draws the following conclusions from the literature. First, different patent-policy

[19] Zheng *et al.* (2020) incorporate patent breadth into Dinopoulos and Segerstrom (2010) to analyze the cross-country effects of patent protection on innovation, FDI, and welfare.

[20] See Sener (2006) for a model in which technology transfer occurs through both FDI and imitation, but he focuses on numerical simulation in his analysis.

instruments may have drastically different effects on R&D and economic growth. Second, there exists some empirical evidence that supports a positive relationship between IPR protection and innovation, but the evidence is stronger for developed countries than for developing countries. Third, the optimal level of IPR protection should balance the social benefit of innovation and the social costs of monopolistic distortions and income inequality. Finally, in an open economy, achieving the globally optimal level of protection requires an international coordination (rather than the harmonization) of IPR protection.

Let me conclude this survey by suggesting potential directions for future research. First, as Acemoglu (2009) suggests, the literature lacks a standardized growth-theoretic framework that can be used to evaluate patent policies quantitatively. In particular, we still lack a systematic framework that can be used to simultaneously analyze the quantitative implications of different patent-policy instruments, such as patent length, patentability requirement, lagging and leading patent breadth, as well as their optimal combination. Second, the Ginarte-Park IPR index (commonly-used by empirical studies) is constructed as an aggregate measure of various patent rights. Given that the theoretical literature has emphasized the asymmetric effects of different patent-policy instruments, it would be interesting if future empirical studies could shed some light on the effects of different patent-policy instruments on innovation. Finally, existing empirical studies mostly focus on the effects of domestic patent protection on domestic innovation. Given that a central question in the open-economy literature is whether Southern IPR protection improves or stifles Northern innovation, it would be interesting if future empirical studies can shed more light on this issue; see Park (2012) for a notable example.

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